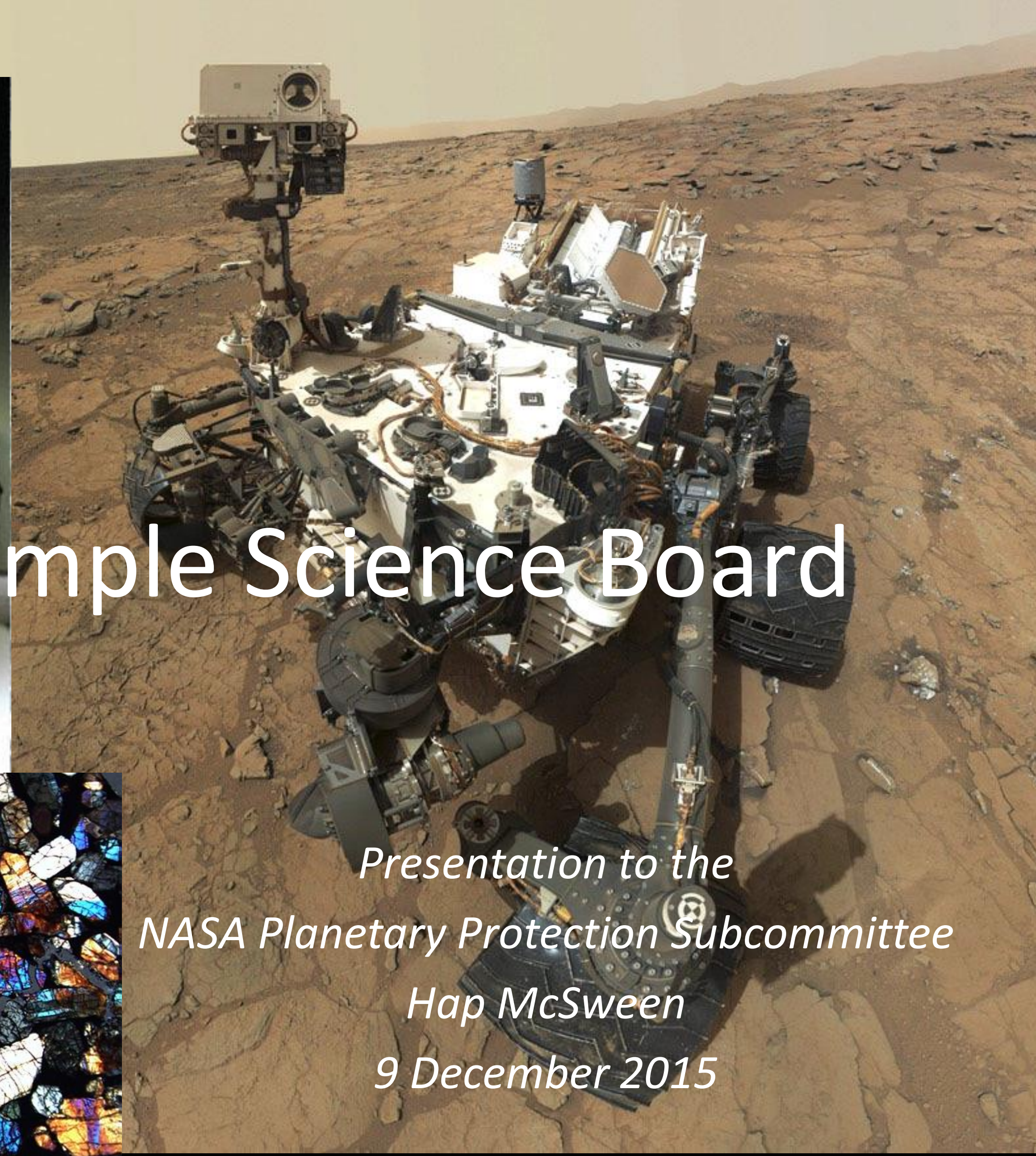
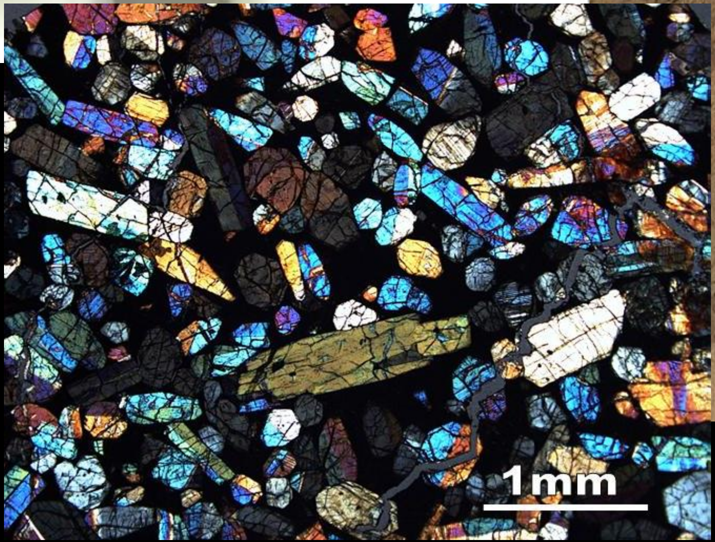
Returned Sample Science Board





Presentation to the

NASA Planetary Protection Subcommittee

Hap McSween

9 December 2015

Returned Sample Science Board (RSSB)

CHARTER

The Mars 2020 Returned Sample Science Board

8 September 2015

Ken Farley, M-2020 Project Scientist
Mitch Schulte, M-2020 Program Scientist
Michael Meyer, MEP Lead Scientist

NASA HQ selected an independent diverse group of scientists that represents the interests of future scientists who could analyze samples collected by Mars 2020 if the samples are returned to Earth.

RSSB: Rationale

One of the core objectives of the Mars 2020 mission is to prepare a scientifically selected and documented cache of samples for possible return to Earth by future missions. Preparation of the most scientifically compelling samples for possible analysis on Earth necessitates inputs and community engagement that cannot be adequately provided by the existing project team nor the Mars 2020 instrument PIs.

For this reason, the Mars 2020 project has chartered a team of scientists drawn from the diverse array of disciplines likely to be involved in the study of the returned samples, referred to as the Returned Sample Science (RSS) Board. This team will counsel the project by providing scientific guidance in the design, implementation, and planned execution of the mission.

RSSB: Structure

1. Co-chairs:
   David Beaty (JPL; Coordinator, Mars Chief Scientist)
   Hap McSween (Univ. of Tennessee; petrology, geochemistry, MER, CAPTEM chair)
2. Science Members: ~10 at-large members elected for deep knowledge and interest in scientific areas relevant to the study of samples from Mars plus 2 ex-officio
   Andrew Czaja (Univ. of Cincinnatti; astrobiology--microfossils, organics, isotopes)
   Elizabeth Hausrath (Univ. of Nevada; astrobiology--aqueous geochemistry, W/R interactions)
   Chris Herd (Univ. of Alberta; petrology, curation, meteorites, E2E-iSAG)
   Munir Humayun (Florida State Univ; radiogenic isotopes,trace elements, meteorites)
   Scott McLennan (Stony Brook Univ; sedimentology, geochemistry, E2E-iSAG, MSL, MER)
   Lisa Pratt (Indiana Univ; astrobiology, stable isotopes, sedimentology, MEPAG Chair)
   Mark Sephton (Imperial College; organic geochemistry, astrobiology, E2E-iSAG, M2020 SDT)
   Andrew Steele (Carnegie Inst. Of Wash; astrobiology, PP, MSL, OCP, M2020 SDT)
   Ben Weiss (MIT; paleomagnetism, geophysics, planetary histories)
   Francis McCubbin (JSC; *ex-officio*, petrology, appointed by JSC to represent curation)
   Yulia Goreva (JPL; *ex-officio*, RSS IS, instrumentation, geochemistry, appointed by M2020 as an interface between M2020 scientists, engineers and RSSB)
3. Observers:
   Michael Meyer (NASA HQ, Observer for Mars Exploration Program, MEP Lead Scientist)
   Betsy Pugel (NASA HQ, Observer for Planetary Protection)
   Lindsay Hays (JPL, Observer for Mars Sample Return Campaign, MSR System Engineer)

RSSB: Responsibilities

Board Responsibilities	1. The Board's primary role is to help with analyses requested by the Project related to the implications of various science-engineering trades, or other kinds of planning options/questions, on possible eventual returned sample science. 2. Work with the Mars 2020 Project Science office in the development of the requirements (Level 2/3/4) that relate to sample quality, sample preservation, or any other matter of relevance to ensuring that the samples are as scientifically useful as possible if they are returned to Earth. 3. Provide technical data/information related to potential future RSS investigations as needed to inform project decision-making. 4. Contribute as needed to formal project-level science planning documents. 5. Maintain adequate documentation of deliberations and recommendations for the benefit of future returned sample science investigators. 6. Provide input, as requested by the MSR campaign, as it directly relates to the 2020 mission and the preservation of sample science
Observer Roles/ Responsibilities	1. In recognition that the topics discussed by the RSS Board may have implications for matters beyond the science of M-2020, three observer roles are established. It is intended that by establishing the ability to expeditiously convey an understanding of the RSS Board's conclusions to these surrounding entities, we will promote convergence, and minimize disconnects. NASA HQ Mars program science. NASA HQ Planetary Protection. Mars Program Office, MSR Campaign Advance Planning. 2. It is intended that the observers will be copied on key correspondence and/or reports of the RSS Board, and that they will be invited to listen to RSS discussions so that they can better understand the rationale for conclusions reached. 3. It is not intended that the observers will contribute technical input to science discussions of the RSS Board, unless requested by the Board's co-chairs.

RSSB: Sunset Clause

It is expected that the NASA-selected RSS Board members for Mars 2020 will serve until establishment of the *Participating Scientist Program* (assume about 1 year before launch), at which time, *new RSS Board positions would be competed*. The reconstituted Board would guide the mission during operations concerning RSS issues, with the overall leadership of the Project Scientist and the Program Scientist. Thus, the RSS Board, as it is constituted in this charter, will be dissolved upon the announcement of competition for Participating Scientists. All scientists who participate in the RSS Board are free to compete for a Participating Scientist role, but this prior service will not guarantee selection.

Examples of RSSB Tasks

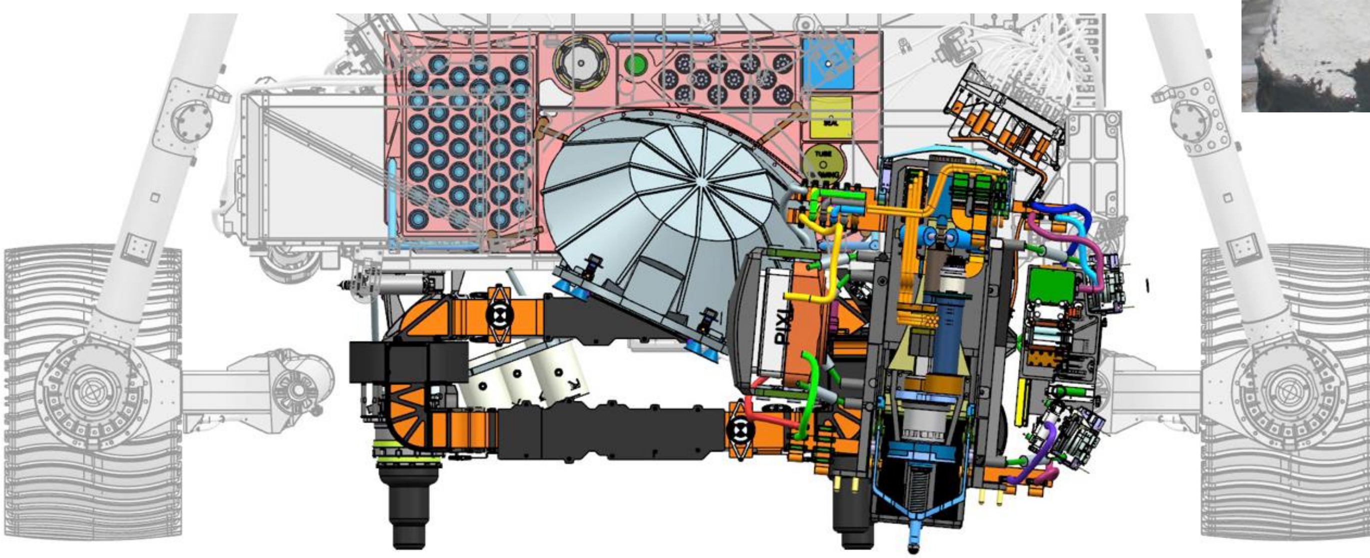
- **Past**
  1. The effect of temperature on returned sample science

- **Current**
  1. Landing site selection from the perspective of returned sample science
  2. Inorganic contamination, specifically tungsten
  3. Magnetic studies

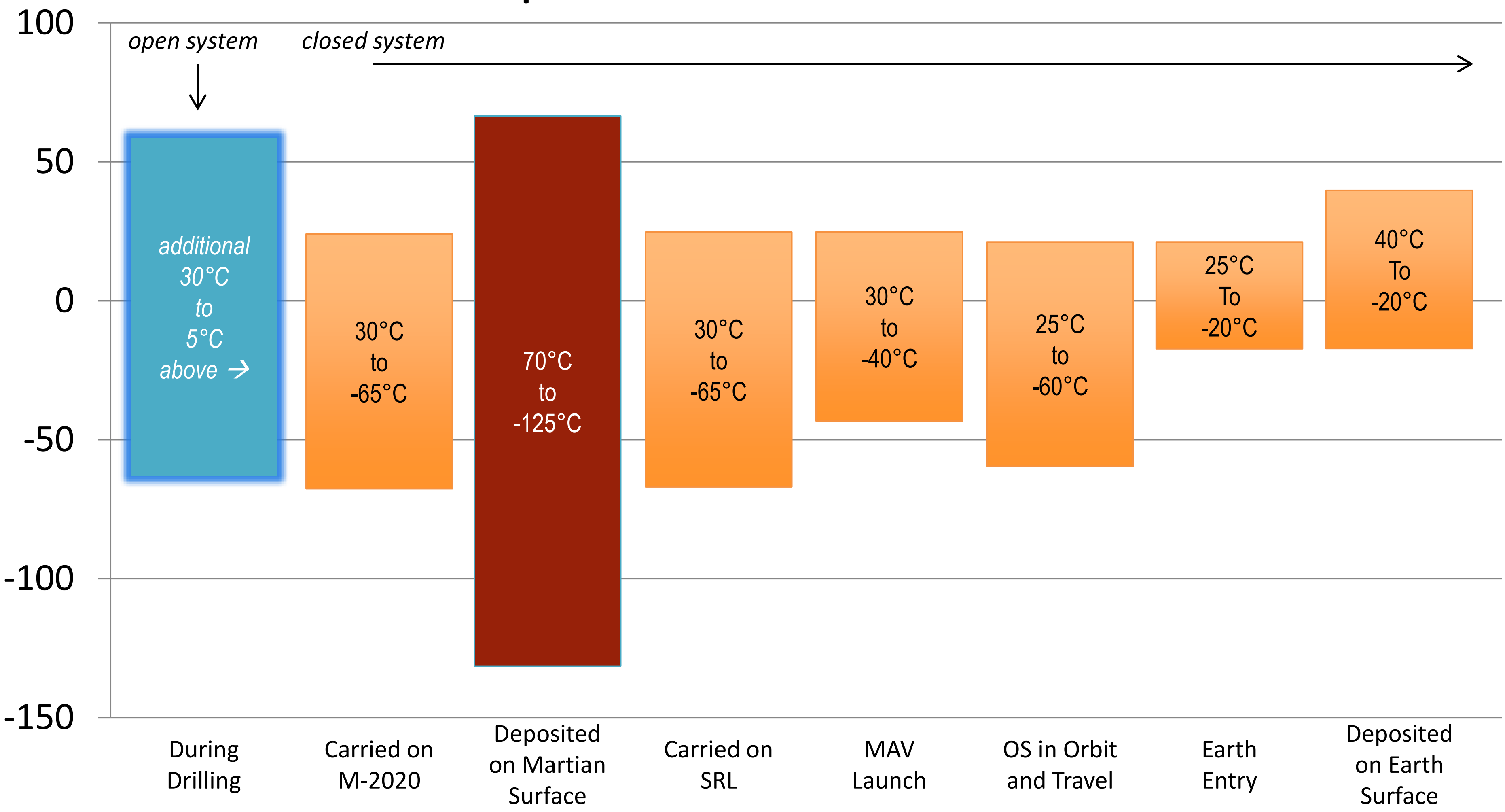
- **Future**
  1. Procedural blanks for organic analyses
  2. Dossier for cached samples

Task: The effect of temperature on returned sample science

- Is the expected maximum sample temperature associated with current M-2020 mission implementation acceptable?
- What is the priority to science for defending current temperature requirements, should there be future engineering requests to increase them?



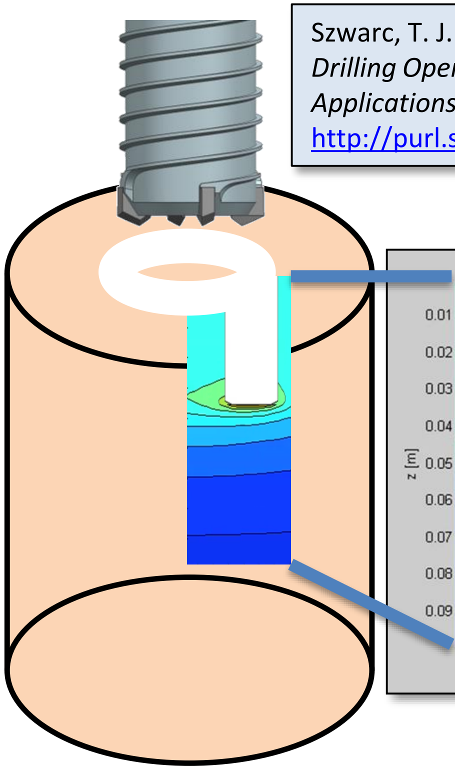
Potential temperature ranges for sample tube environments



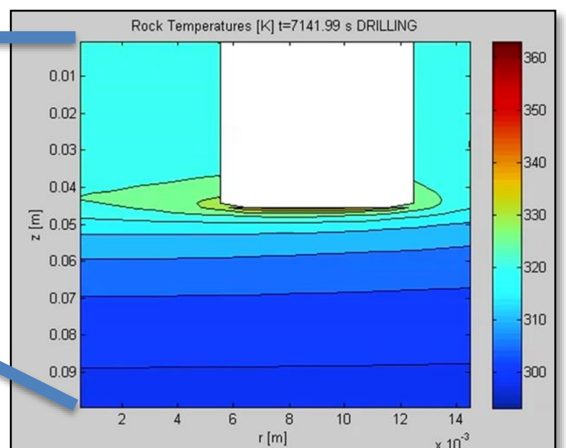
Bottom line: the samples will experience the highest temperature range while sitting on the surface (where there is less insulation and less thermal inertia of surrounding spacecraft) and during drilling.

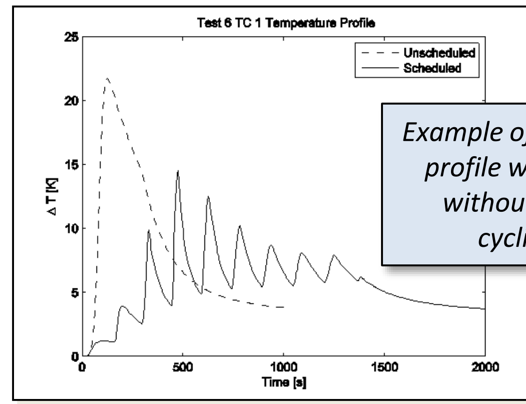
Sample Temperatures with Duty Cycling

- Expect to meet existing acquisition (pre-sealing) sample temperature requirements
  - Depending on landing site, during worst-case-hot conditions expect to use duty-cycling of corer and/or additional operational constraints (such as not coring during peak diurnal temperatures in summer) to keep sample temp below required temperature (30C or estimated maximum annual surface temp, whichever higher)
- Simulation tool developed by Tim Szwarc (member of the M2020 Coring team) for his doctoral dissertation
  - Accurately predicts thermal profile during core acquisition
    - Results have been correlated by test data using instrumented rocks
  - Schedules duty cycling of coring operation based on mechanism telemetry, radial location within core sample to control temperature, and target temperature
  - Could be used to choose duty cycling for M2020 core acquisition

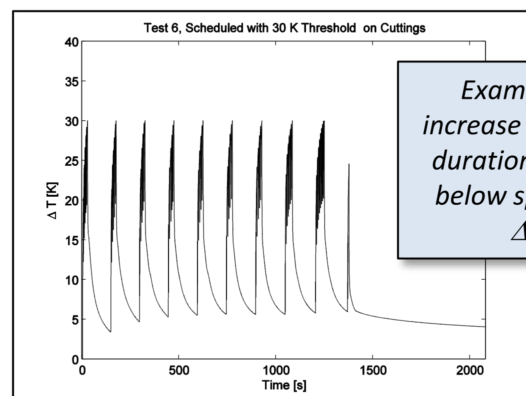


Szwarc, T. J. (2013). *Thermal Modeling of Coring and Drilling Operations for Solar System Exploration Applications* (Doctoral dissertation). http://purl.stanford.edu/kx909xd7066



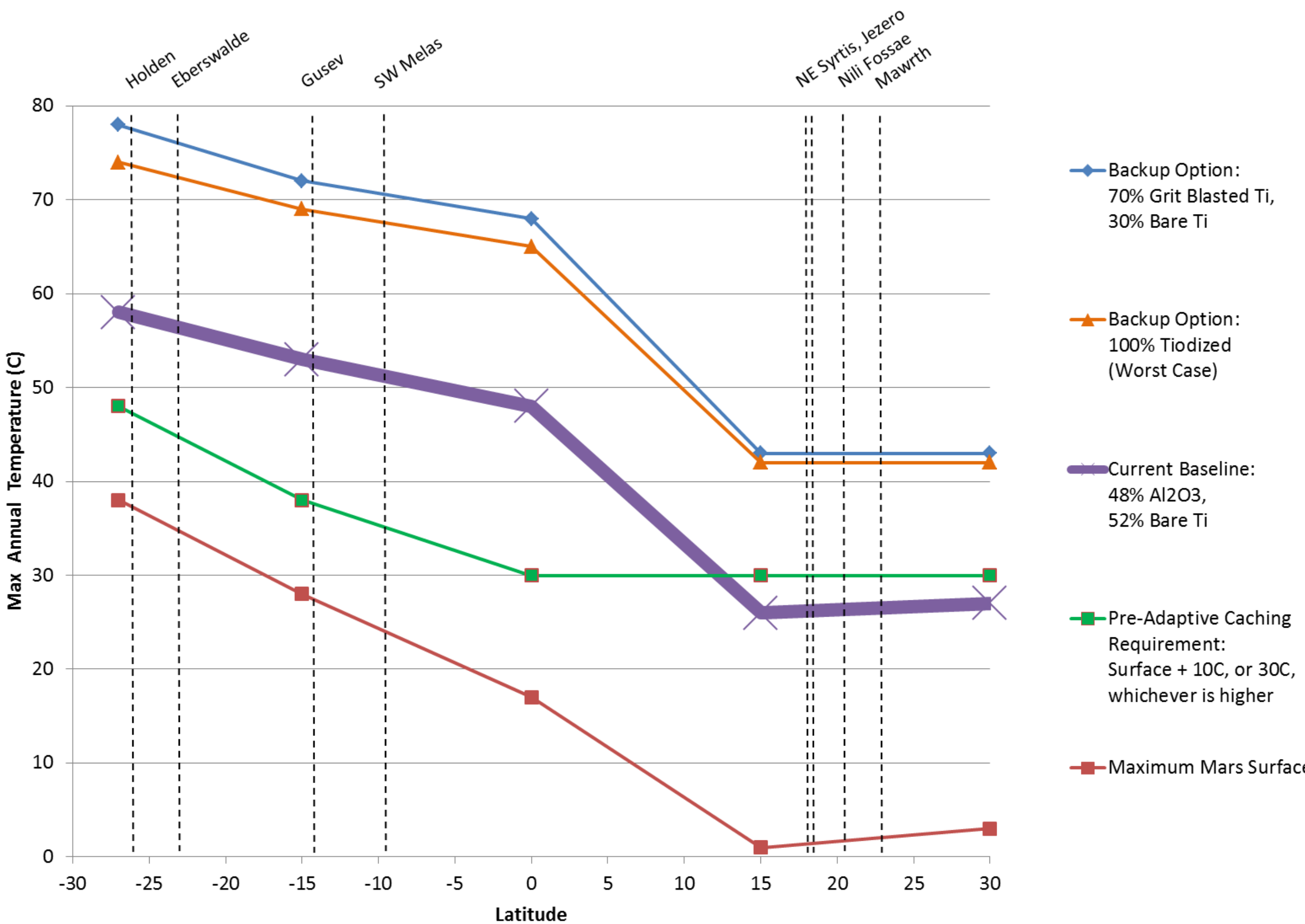


Example of thermal profile with and without duty cycling



Example of increase in coring duration to stay below specified ΔT

Predicted Temperatures Are Site Specific

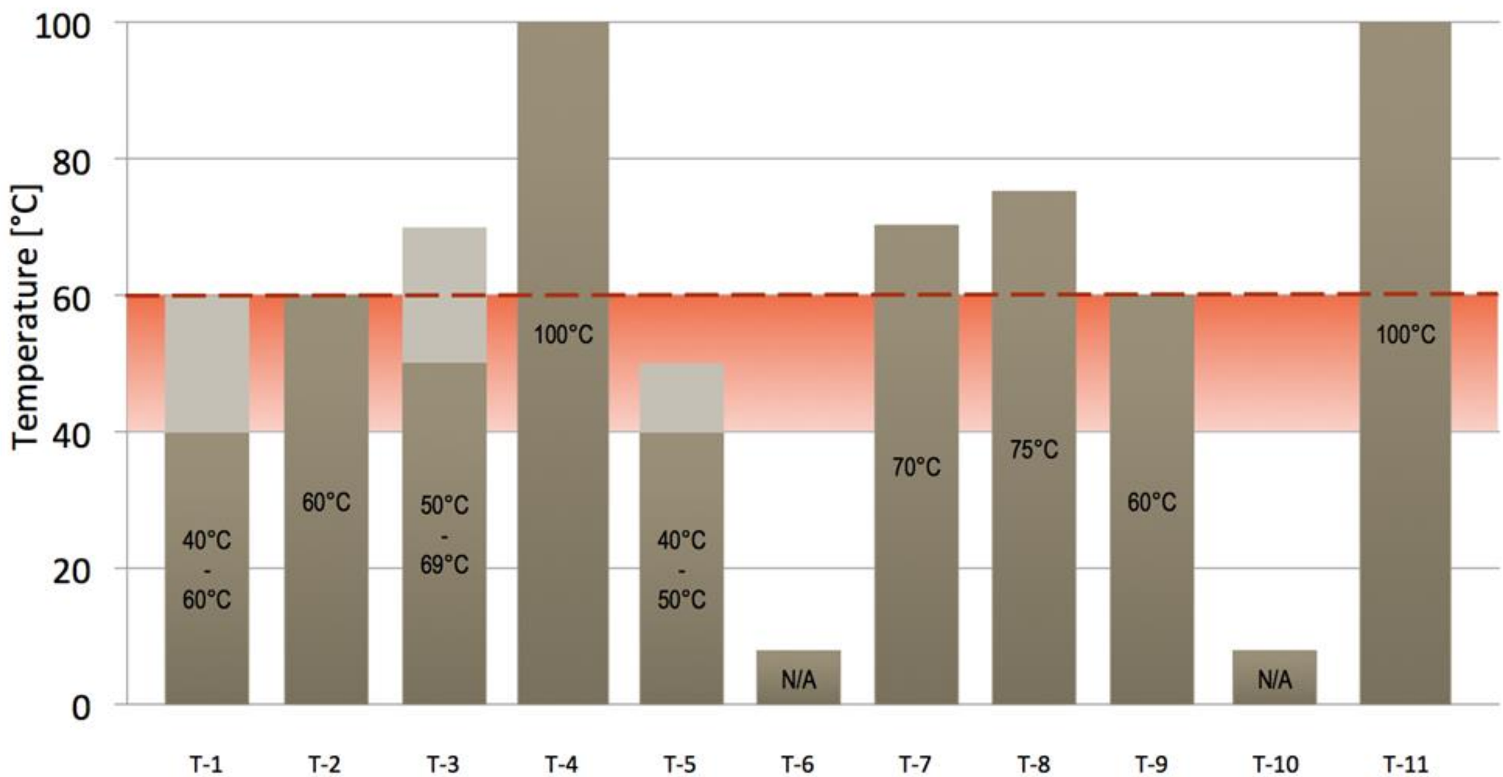


Relationship between latitude and maximum temperature, from the time of placement on the martian surface until 10 years later. Modelling by Matt Redmond and Pradeep Bhandari.

Investigations Considered

#	Scientific Investigation where thermal excursions may have an adverse effect on the science outcome
T-1	Preservation of organic compounds
T-2	Stable isotope effects caused by non-reversible reactions and diffusion
T-3	Effects on minerals: sulfates, phyllosilicates, opaline silica, zeolites
T-4	Water content of soils or rocks
T-5	Amorphous materials
T-6	Possible effect of temperature on putative martian organisms
T-7	Possible temperature-related effect on oxidation/reduction
T-8	^{4}He diffusion in apatite
T-9	Fission tracks, cosmic ray tracks, and solar flare tracks
T-10	Trapped gases.
T-11	Magnetic studies

Maximum Allowed Temperatures



Graphical representation of the maximum allowed temperature (or temperature range, gray areas) for the 11 evaluated temperature-sensitive scientific investigations.

Direct impact on M2020 engineering development: Following the RSSB temperature report, M2020 engineers produced new models, with calculations for various degrees of Al_2O_3 coating for maximum temperature not to exceed 60^{o}C in *any part* of the sample tube (as opposed to the average tube).

Abbreviated Summary of Findings

- The current mission baseline sample tube may reach 60^{o}C, depending on site. This is an acceptable limiting temperature for most kinds of geological materials and planned sample investigations. However, an engineering goal of 40-50 ^{o}C would be desirable for analyses of some organic compounds, hydrated sulfates, and amorphous materials.

- Lower temperatures can be satisfied without additional effort for landing sites in the northern hemisphere. High temperature effects can be mitigated if the headspace gas in the sample tube is kept low. In any case, headspace gas should be captured and analyzed on return to Earth.

- Heating during drilling (open system) is potentially more damaging than during caching (closed system).

- Temperature constraints for each kind of investigation are documented, so appropriate defense against sample temperature increases can be formulated once the landing site has been selected and geology is better constrained.

Task: Inorganic Contamination

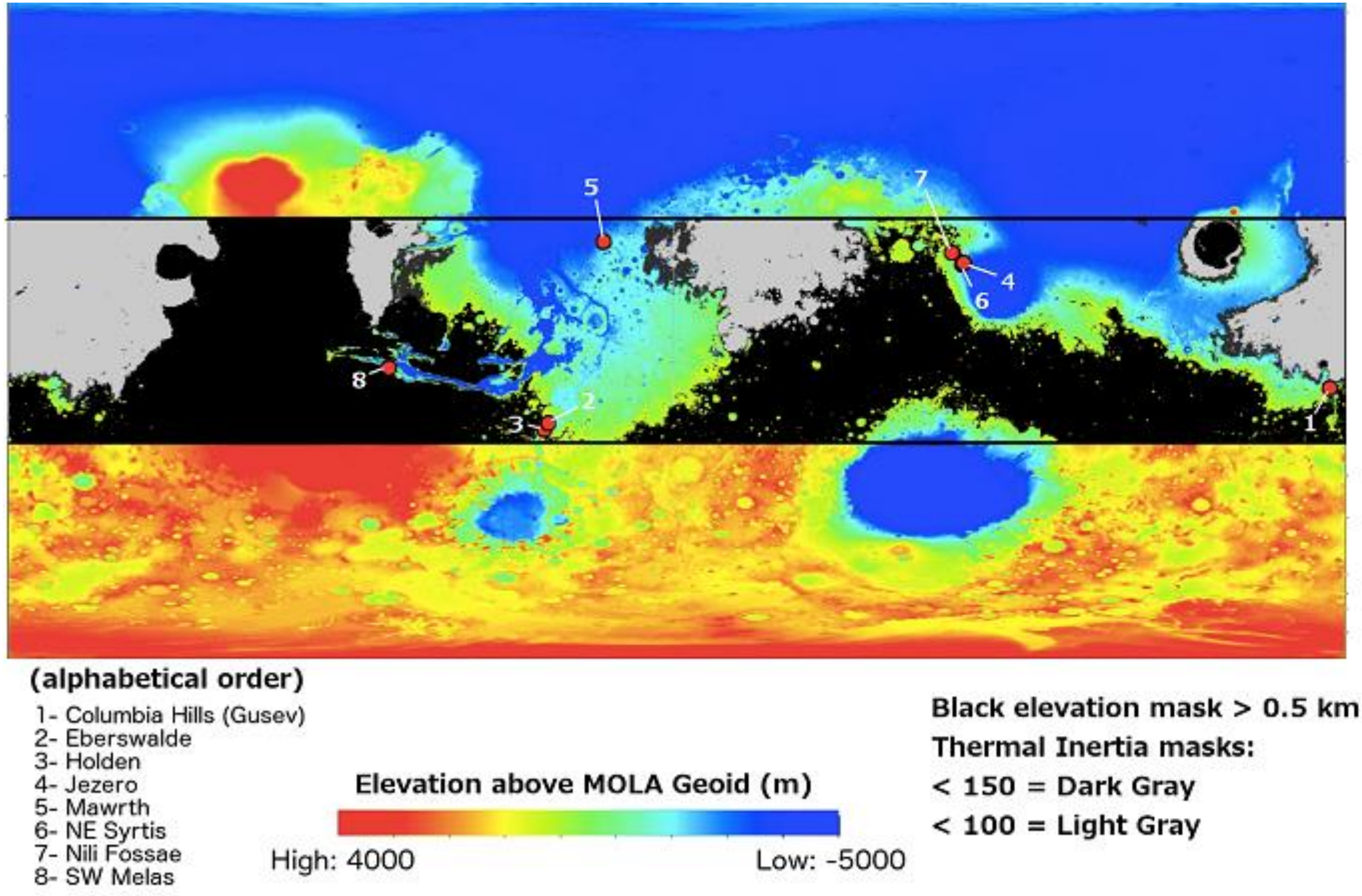
The proposed implementation of the Mars-2020 sample collection and encapsulation system would/could have the effect of adding small amounts of certain inorganic components to at least some samples. Is this contamination acceptable?

<u>Of particular interest:</u>

1. Samples collected using the WC bit appear to be orders of magnitude out of compliance for tungsten.
2. The system may not be compliant for Ni, Zn, Mn, Sr, and Zr. Is the system close enough?
3. Is the system able to meet the current working requirement for Pb? If not, is the associated science important?
4. Is C contamination in the form of WC, diamond, or the C in metal alloys a concern?

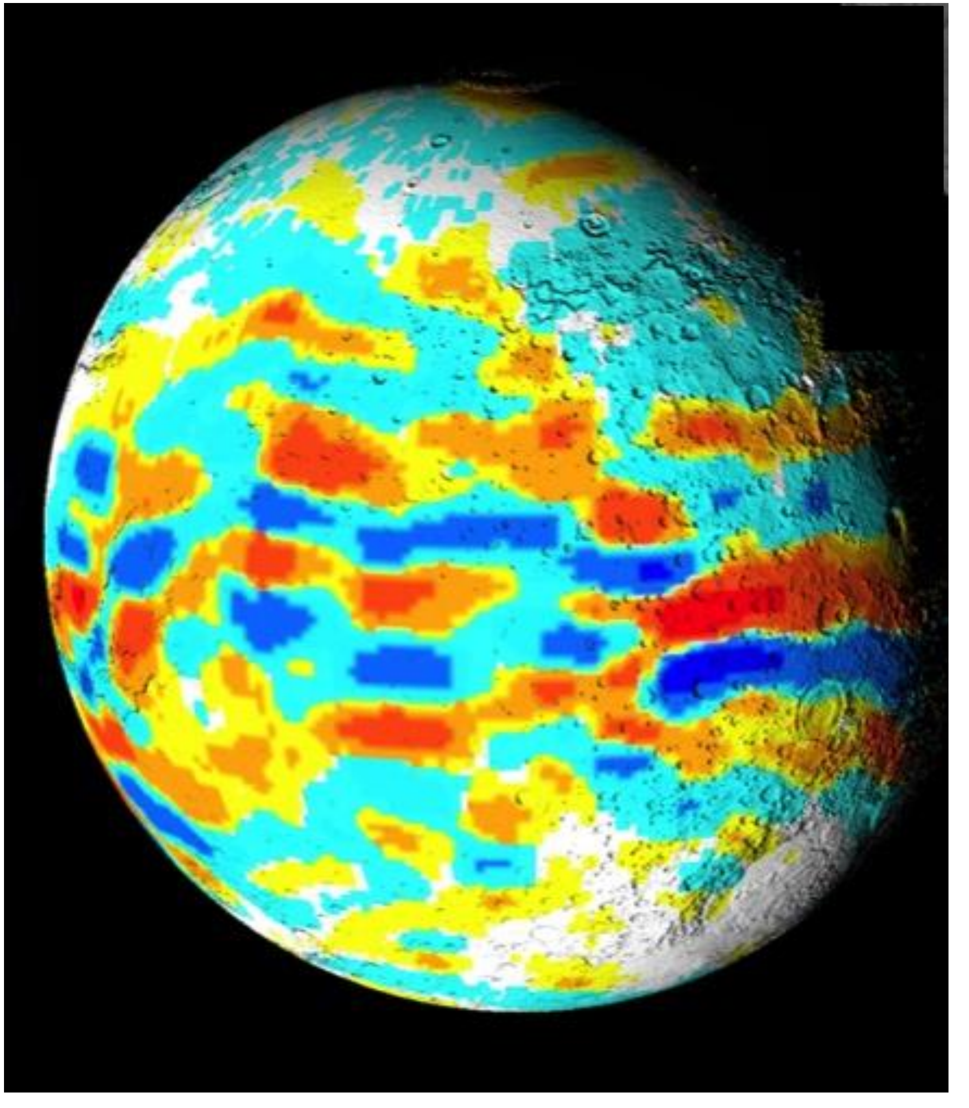
<u>Initial Conclusion:</u> The tungsten issues would have a significant effect on a key RSS investigation (W-Hf geochronology). More attention needed.

Task: Landing Site Selection



Task: Magnetic Studies

- Mars does not have a magnetic field today
- However, ancient Noachian rocks have strong remnant magnetic anomalies
- An evaluation of the effect of the magnetic fields associated with the actuators (and in particular, the one that rotates the drill) on the samples is needed



Summary

- The RSSB functions as an organ within the M-2020 project, acting as a component of the overall science team and reporting to the Project Scientist.
- The RSSB is a group of independent scientists chosen to be representative of a much larger population of sample scientists in the broader scientific community.
- The RSSB evaluates questions presented to it by the Project Scientist from the point of view of future sample analysts, and renders expert judgments.
- The RSSB values the opportunity to maintain communication with NASA Planetary Protection and with the MSR concept development.